Chemistry Quiz
Thermochemistry
Instructor's Version

Answers to Section I (Multiple Choice)

1.	**C**
2.	**B**
3.	**A**
4.	**B**
5.	**D**
6.	**D**
7.	**C**
8.	**E**
9.	**A**
10.	**C**

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Answers to Section II (Free Responses)
Time Limit: You have 30 minutes to complete this section.
Scoring: 60 points total; question 1 is worth 30 points and question 2 is worth 30 points; points for each section are indicated within the question.

1. An experiment is to be performed to determine the molar enthalpy of neutralization of a weak acid and a strong base. Acceptable high school chemistry lab equipment is available as well as a supply of standard 1.0 molar $HC_2H_3O_2$ and standard 1.0 molar KOH.

A. List the equipment you would use to complete the experiment. (6 points)

Answer:
Equipment needed: thermometer (or temperature probe), a calorimeter (reaction vessel), balance (or pipet/graduated cylinder)

B. What data would you collect? (6 points)

Answer:
Data to collect: initial temperature of solutions just prior to reaction and final temperature (maximum) after mixing; quantity (mass or volume) of acid and of base.

C. Describe what you would do with the data to obtain the standard molar enthalpy of neutralization. (10 points)

Answer:
Determine the heat produced by the reaction using $q = mc\cdot\Delta T$. Multiply the mass of the final solution (sum of masses or volumes of acid & base) by the specific heat capacity of the solution (assume same as water) and then multiply by the change in temperature that occurred (final – initial).

To get the **molar** heat of neutralization, divide the heat produced by the moles of water produced (via limiting reactants - look at stoichiometry), or moles acid or base if used same volume of each.

D. When ten trials of this experiment were completed, the average result was –55.0 kJ/mol. The accepted value for the stand molar enthalpy of neutralization of a weak acid by a strong base is –57.7 kJ/mol. Suggest two likely sources of experimental error that could account for the low average result. (8 points)

Answer:
Experimental errors: heat loss to calorimeter or air; incomplete transfer of acid or base; incomplete mixing; did not allow temperature to get to maximum before record final temperature [about anything that would give a lower than needed final temperature].

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2. Propane, C_3H_8, is a hydrocarbon that is commonly used as a fuel for cooking.

A. Write a balanced equation for the complete combustion of propane gas, which yields CO_2 (g) and H_2O (l). (3 points)

Answer:

$$C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$$

B. Calculate the volume of air at 25^{0}C and 1.00 atmosphere pressure that is needed to burn completely 15.0 grams of propane. Assume that oxygen has a density of 1.31 g/L at 25^{0}C and that air is 21.0% O_2 by volume. (9 points)

Answer:

$$15.0\ \text{g}\ C_3H_8 \times \frac{1\ \text{mol}\ C_3H_8}{44.0\ \text{g}\ C_3H_8} \times \frac{5\ \text{mol O}}{1\ \text{mol}\ C_3H_8} \times \frac{32.0\ \text{g}\ O_2}{1\ \text{mol O}} = 54.5\ \text{g}\ O_2$$

$$54.5\ \text{g}\ O_2 \times \frac{1\ \text{L}\ O_2}{1.31\ \text{g}\ O_2} \times \frac{100\ \text{L air}}{21.0\ \text{L}\ O_2} = 198\ \text{L air}$$

C. The heat of combustion of propane is −2,220 kJ/mol. Calculate the heat of formation, ΔH_f^0, of propane given that ΔH_f^0 of H_2O(l) = −285.3 kJ/mol and ΔH_f^0 of CO_2(g) =−393.5 kJ/mol. (9 points)

Answer:

$$\Delta H^0_{comb} = \left[3\Delta H^0_f\left(CO_2\right) + 4\Delta H^0_f\left(H_2O\right)\right] - \left[1\Delta H^0_f\left(C_3H_8\right) + 5\Delta H^0_f\left(O_2\right)\right]$$

$$-2220 = \left[2(-393.5) + 4(-285.3)\right] - \left[1(X) + 5(0)\right]$$

$$X = \Delta H^0_f(C_3H_8) = -101.7\ \frac{kJ}{mol}$$

D. Assume that all of the heat given off in burning 20.0 grams of propane is transferred to a quantity of water (C_p = 4.184 J/g•K). The water increases in temperature from 18.0^{0}C to 37.0^{0}C. What volume (L) of water was heated? (9 points)

Answer:

Heat produced by burning 20.0 grams of propane:

$$20.0\ \text{g}\ C_3H_8 \times \frac{1\ \text{mol}\ C_3H_8}{44.0\ \text{g}\ C_3H_8} \times \frac{2220\ \text{kj}}{1\ \text{mol}\ C_3H_8} = 1009\ \text{kJ}$$

is absorbed by the water:

$$q = mc_p\Delta T$$

$$1009\ \text{kJ} = (1.009 \times 10^6\ \text{J}) = \text{m}\left(4.184\ \frac{\text{J}}{\text{g·deg}}\right)(37.0 - 18.0)\left(\frac{1L}{1000g}\right)$$

$$m = 1.27 \times 10^4\ g\ H_2O = 1.27 \times 10^4\ m\text{L}\ H_2O = 12.7\ \text{L}\ H_2O$$

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